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A LIGHT CONTROL ELEMENT, A METHOD OF MANUFACTURING THEREOF, AND MACHINE USED FOR PRODUCTION THE LIGHT CONTROL ELEMENT

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A LIGHT CONTROL ELEMENT, A METHOD OF MANUFACTURING THEREOF, AND MACHINE USED FOR PRODUCTION THE LIGHT CONTROL ELEMENT

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[There are no amendments to this patent.]

[Title of the invention]

A light control element, method of manufacturing thereof, and a machine used for production of the light control element

[Abstract] (Rewritten)

[Objective] The objective of the present invention is to produce a light control element having a flat surface so that adhesion is easy when multiple elements are used in combination, and, at the same time, the side faces as well as the front face and the back face, can be used for incident and exit surface of the light and which has low transmission loss, and [the objective is] to provide a method of manufacturing thereof and the machine used for production of the light control element.

[Constitution] Many transparent flakes having an index of refraction different from the index of refraction of the light guide material are dispersed in light guide 10 having flat surface 12, and the flakes are oriented at an angle other than 0°. Different types of light guides can be applied to the above-mentioned element, or a mirror can be applied to the surface. In order to arrange the transparent flake at the specified angle, a nozzle having a partitions arranged to form the specified angle can be used, and extrusion molding can be performed.

[Explanation of codes] [*Copied from p. 5 or original*]

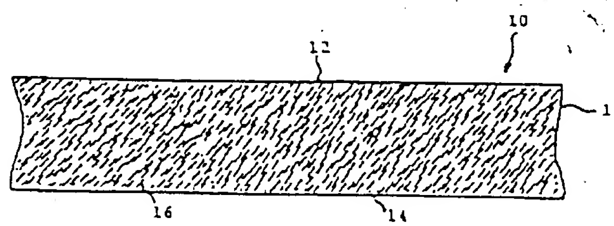
10: light control element

11: Light guide

12: Surface of the light guide

14: Backside of the light guide

16: Transparent flake



[Claims of the invention]

[Claim 1] A light control element in which many transparent flakes having an index of refraction different from the index of refraction of the light guide and having a flat surface and which are comprised of a transparent resin having a specified index are dispersed in such a manner that the surface of the transparent flake forms a specified angle other than 0°.

[Claim 2] The light control element specified in claim 1 above in which the light guide is a sheet-like material having a front surface and back surface that are parallel, and when

an incident ray enters perpendicular to the surface, and is reflected at the surface of the above-mentioned transparent flake and is transmitted toward the back surface, the above-mentioned specified angle is set such that the angle of the light ray transmitted toward the back surface is greater than the critical angle required for total reflection.

[Claim 3] The light control element specified in claim 1 above wherein the above-mentioned specified angle is set at the angle of polarization so that Brewster polarization can be achieved by the above-mentioned transparent flake.

[Claim 4] The light control element specified in at least one of the above-mentioned claims 1 through 3 wherein different types of transparent resin layers are applied over the entire surface of the above-mentioned light guide.

[Claim 5] The light control element specified in at least one of the above-mentioned claims 1 through 4 wherein $\lambda/4$ sheet or $\lambda/4$ film is applied to the entire surface of the above-mentioned light guide.

[Claim 6] The light control element specified in at least one of the above-mentioned claims 1 through 4 wherein a light reflecting means is applied over the entire surface of the above-mentioned light guide.

[Claim 7] The light control element specified in at least one of the above-mentioned claims 1 through 4 wherein a polarizing film is applied over the entire surface of the above-mentioned light guide.

[Claim 8] The light control element specified in at least one of the above-mentioned claims 1 through 7 wherein the transparent resin used as the material for the above-mentioned light guide is comprised of a methacrylic resin, a heat resistant acrylic resin,

allyl resin, polyethylene resin, polystyrene resin, polycarbonate resin, cellulose resin, silicone resin, or vinyl chloride resin.

[Claim 9] The light control element specified in at least one of the above-mentioned claims 1 through 8 wherein the above-mentioned transparent flake is comprised of basic lead carbonate, mica, inorganic glass, or one of said materials with a metal oxide coating.

[Claim 10] The light control element specified in at least one of the above-mentioned claims 1 through 10 wherein the long side of the above-mentioned transparent flake is 1 to 1,000 μ, and the thickness is in the range of 1/2 to 1/200 of the shorter side.

[Claim 11] The light control element specified in at least one of the above-mentioned claims 1 through 10 wherein the amount of the above-mentioned transparent flake is selected in such a manner that the total projected surface area of the transparent flake is greater than the projected surface area of the above-mentioned light guide when light enters the light guide from a given direction.

[Claim 12] The light control element specified in at least one of the above-mentioned claims 1 through 11 wherein a light reflecting layer or light absorbing layer is applied to one of the above-mentioned transparent flake layers.

[Claim 13] The light control element specified in at least one of the above-mentioned claims 1 through 3 and claims 8 through 12 wherein at least one surface of the above-mentioned light guide is a rough surface.

[Claim 14] The light control element specified in at least one of the above-mentioned claims 1 through 3 and claims 8 through 12 wherein the transparent resin layer having one rough surface is applied to one surface of the above-mentioned light guide.

[Claim 15] A method of manufacturing a light control element that includes a process wherein hot-melting is performed for a transparent resin with a specified index of refraction, mixing of many pieces of transparent flake having a different index of refraction from the index of refraction of the above-mentioned material is performed, and the mixture is extrusion molded via a nozzle having many partitions so that multiple of rectangles or parallelograms having a ratio of long side to short side of at least 2:1 are formed.

[Claim 16] A machine used for production of the light control element which has a nozzle used for extrusion of a resin that forms the light control resin in which many partitions are installed inside the nozzle to produce many rectangles or parallelograms having a ratio of long side to short side of at least 2:1.

[Detailed explanation of the invention]

[0001]

[Field of industrial application] The present invention pertains to a light control element, and it further pertains to a light control element made of a light control resin material that provides diffusion and controls the polarization in the direction of travel of the light, a manufacturing method thereof, and the basic lead carbonate crystal.

[0002]

[Prior art] For resin materials providing light diffusion, those produced by adding a light dispersing agent to a transparent resin, or forming a pattern on the surface of the resin are known. Also, for light control resin material that provides diffusion of light with a controlled direction of the light, those made of materials shaped like lenses or prisms are

known. Meanwhile, for the polarizing element, a birefringence type element such as a Nicol and Glan-Thompson element, a reflective type element such as pile or plate, and polarizing beam splitters, and dichroic types and polarizing films are known.

[0003]

[Problems to be solved by the invention] In the light control element having conventional diffusion characteristics, the shape of the surface is utilized, thus, the surface is not flat and when these elements are formed into a composite, adhesion is inadequate. Furthermore, the front and back surfaces can be utilized, and the quantity of light transmitted by the polarizing element is reduced to almost one-half, and the dimensions of the element are large. Based on the above background, the primary objective of the present invention is to produce a compact light control element having a flat surface to provide good adhesion when multiple elements are used in the form of a composite, wherein the side faces, as well as the front surface and back surface, can be utilized for incidence and emission, a sudden decrease in the quantity of light does not take place. The secondary objective of the present invention is to provide a simple method of manufacturing the above-mentioned light control element, and a device used to produce the light control element.

[0004]

[Problems to be solved by the invention] In order to achieve the above-mentioned primary objective of the present invention, the light control element of the present invention is produced by dispersing many pieces of transparent flake having an index of refraction different from the index of refraction of a light guide having a flat surface and is comprised of a transparent resin having a specified index of refraction in such a manner that the

surface of the transparent flake forms a specified angle.

[0005] In other words, according to the present invention, a light control element can be produced in which many pieces of transparent flake having an index of refraction different from the index of refraction of the light guide having a flat surface and which is comprised of a transparent resin having a specified index are dispersed in such a manner that the surface of the transparent flake forms a specified angle other than 0°.

[0006] Furthermore, in order to achieve the secondary objective, orientation of the transparent flake is achieved by installing multiple of partitions in the exit nozzle of the molding machine in the present invention during manufacture of the above-mentioned light control element by extrusion molding.

[0007] In other words, according to the present invention, a method of manufacturing a light control element that includes a process wherein hot-melting of a transparent resin with a specified index of refraction, mixing of many transparent flakes having an index of refraction different from the index of refraction of the above-mentioned transparent resin is performed, and the mixture is extrusion molded via a nozzle having many partitions so that multiple rectangles or parallelograms having a ratio of long side to short side of at least 2:1 can be formed. Furthermore, according to the present invention, the machine used for production of the light control element has a nozzle used for extrusion of the resin that forms the light control resin, and many partitions are installed inside of the nozzle so as to produce many rectangles or parallelograms having a ratio of long side to short side of at least 2:1.

[0008]

[Effect] Distribution and polarization of incidence light can be freely controlled in the light control element of the present invention having the above-mentioned structure through adjustment of the arrangement of the transparent flakes. Furthermore, according to the manufacturing method and device used in the present invention, light control elements with the desired properties can be easily produced.

[0009]

[Application examples] In the following, a suitable application example of the present invention is explained with drawings. Fig. 1 is a partial cross section view that shows an application example of the light control element of the present invention. Light control element 10 is produced by dispersing multiple transparent flakes 16 in sheet-like light guide 11 comprised of a transparent resin material, and the angle and the dispersed pattern is set at a constant value. For the transparent resin materials, synthetic resins such as methacrylic resins, heat resistant acrylic resins, allyl resins, polyethylene resins, polystyrene resins, polycarbonate resins, cellulose resins, silicone resins, and vinyl chloride resins can be used. As for the dispersed transparent flake 16 arranged in the above-mentioned transparent resin, basic lead carbonate monocrystals, which are commonly used for heat reflective acrylic resin plates, can be used, or a similar material can be used as well.

[0010] In the case of basic lead carbonate crystals, the thickness of the material is approximately 0.1 μm, and the width is approximately 15 μm, as shown in Fig. 2. It should be noted that in a conventional heat-reflective acrylic resin plate, the orientation of the arrangement of the basic lead carbonate crystals, that is the orientation of the front

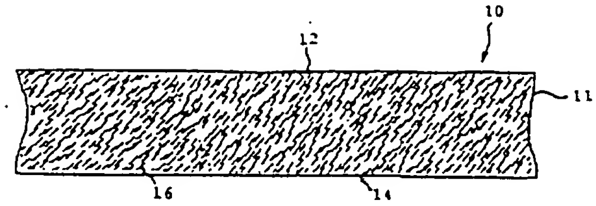
surface or the back surface is parallel with the front surface or back surface of the resin plate; on the other hand, in the case of the present invention, a constant angle other than 0° is used as explained below.

[0011] In addition to basic lead carbonate crystals, mica, inorganic glass, or those materials coated with a metal oxide, etc. can be used for transparent flake 16. And the long side of transparent flake 16 is 1 μm~1,000 μm, and the thickness is 1/2~1/200 of the short side. Furthermore, instead of the above-mentioned coated film, a material having a light-reflective layer or a light-absorbing layer applied to at least one surface of transparent flake 16 can be used instead of coating the above-mentioned material.

[0012] Fig. 3 is a partial cross section view that shows an application example when transparent flake 16 is arranged perpendicular to front surface 12 and back surface 14. In this application example, when the incident ray enters perpendicular to surface 12 of light guide 11, the incident ray is emitted from back surface 14 without being reflected by transparent flake 16. On the other hand, incident rays having a different angle from that of the incident ray shown in the figure, that is, off-axis disturbances that enter surface 12 are reflected and dispersed by transparent flake 16, thus, the light is hardly emitted from back surface 14. It should be noted that multiple transparent flakes 16 are also included in application examples in the other figures that follow, but clarity, the number of transparent flakes shown are greatly reduced in those figures.

[0013] Fig. 4 is a partial cross section view that shows the case where transparent flake 16 is arranged at an angle other than 90° to surface 12 of the light guide 11. In this application example, when an incident ray travels parallel to the orientation of the

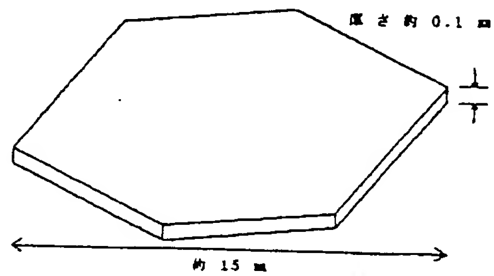
[Fig. 1]



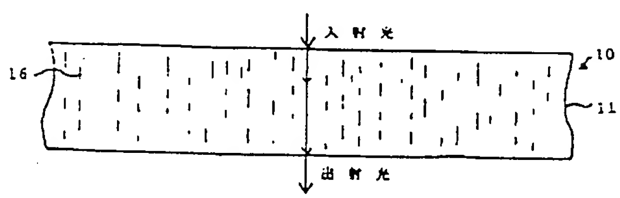
[Fig. 2]

Thickness: approximately 0.1 mm

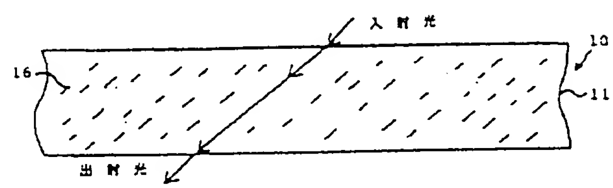
Width: approximately 15 mm



[Fig. 3]



[Fig. 4]



transparent flake 16 (in strict terms, when the direction of the incident ray that enters light guide 11 and the direction of the transparent flake 16 are parallel), reflection of the incident ray does not take place at the transparent flake, and the light is released from the back surface 14. In this case also, disturbance light that enters surface 12 is reflected and dispersed by transparent flake 16; thus, the light is hardly emitted from back surface 14.

[0014] In the case of the structures shown in Fig. 3 and Fig. 4, the amount of transparent flake 16 mixed is preferably determined by the method shown below. It is arranged in such a manner that the total projected area of the transparent flake 16 is greater than the projected area based on light guide 11 when light enters from a given direction for light guide 11.

[0015] Fig. 5 shows the partial cross section view of the traveling direction of the incident ray after being reflected by the transparent flake 16 as the incident ray entered perpendicular to surface 12 of light guide 11. As shown in Fig. 5, the light reflected by the transparent flake 16 travels at the critical angle or an angle greater than said angle toward back surface 14, and is reflected at the back surface 14. Therefore, the light reflected at the back surface 14 is transmitted inside light guide 11 toward the right in the figure and is emitted from side 18 of light guide 11.

[0016] Fig. 6 is the partial cross section view that shows the case where the light control element of the present invention is used as a polarizer for separation of the P wave and the S wave. In this example, emission of the P wave from the back surface 14, and emission of the S wave from the side face 18 are shown. As shown in the figure, it is necessary for the P wave in the incident wave to pass through transparent flake 16 for the P

wave to be released from the back surface 14, in which case, it is necessary to set the angle of transparent flake 16 so that the front surface 12 is the angle of polarization. The above-mentioned structure can be used as a polarizer for liquid crystal displays instead of conventional polarizing films.

[0017] Fig. 7 is the partial cross section view of the polarized diffusion plate made the light control element of the present invention used for liquid crystal displays. The light released from the backlight, which is not shown in the figure, passes through the polarized diffusion plate and enters the liquid crystal and is emitted through polarized film 21.

[0018] Fig. 8 is a diagram that shows the case where the light control element of the present invention is applied to the headlights of an automobile. Thus, when light control element 10 is used as a cover for headlights, the P wave alone is transmitted and emitted, as a result, irregular reflection on the surface of the road can be reduced, and glare to on-coming traffic can be reduced. In the past, polarized films were used for the same purpose, but the transmission of light was inadequate, and the quantity of light was reduced, but in the case of the element of the present invention, the above-mentioned disadvantages do not exist.

[0019] Fig. 9 shows a partial cross section view of an application example wherein layer 20 comprised of a material such as a transparent resin is applied to one surface of light guide 11 of the light control element 10 of the present invention, and retrieval of the S wave is made easy. For the above-mentioned transparent resin layer 20, an acrylic resin, etc. can be used.

[0020] Fig. 10 shows a partial cross section view of an application example wherein in addition to the structure shown in Fig. 9, λ/4 sheet or λ/4 film 11 is applied to the outer surface of transparent resin layer 20, and mirror 24 also is applied to said surface for mirror reflection. When the above-mentioned structure is used, the P wave alone in the incident wave that includes the P wave and S wave is transmitted through the λ/4 film 22, and becomes the S wave, and returns as it is reflected by mirror 24. Thus, the P wave and S wave are separated, and travel along the transparent resin layer 20 in opposite directions, as a result, it can be divided in the vertical direction shown in the fig.

[0021] Fig. 11 is a partial cross section view that shows the state where the S wave was applied to the structure shown in Fig. 9. In this case, the majority of the S wave is reflected at transparent flake 16 and travels toward the end face along transparent resin layer 20. As a result, the light released from the surface (surface at right side of the fig.) of the transparent resin layer 20 is reduced.

[0022] Fig. 12 is a partial cross section view that shows the state where the P wave was applied to the structure shown in Fig. 9. In this case, the P wave passes through transparent flake 16, and travels straight ahead via transparent resin layer 20, it is emitted from the surface (surface of right side of the figure).

[0023] Fig. 13 is a partial cross section view that shows the case where mirror 24 that serves as a mirror reflecting surface is applied over the entire surface of the element of the application example shown in Fig. 3. In this example, transparent flake 16 is arranged perpendicular to surface 12 of the light guide 11 as shown in the figure; thus, the incident ray travels straight through the light guide 11, and is reflected at the mirror 24, and returns

in the opposite direction from which it entered. In this example, when light travels in a direction other than perpendicular to surface 12, it is reflected at transparent flake 16; thus, the light does not reach mirror 24, and reflection at the mirror does not occur. The above-mentioned structure can be utilized for road signs that reflect the headlight beams of automobiles, etc.

[0024] Fig. 14 is a cross section view that shows a modification of the application shown in Fig. 9. In this application example, the exposed surface of the transparent resin layer 20A forms a matt surface having a textured surface. The S wave is emitted from the exposed matt surface in the direction shown in the figure. It should be noted that the P wave travels straight forward as in the case of the example shown in Fig. 9. Also, one surface of light guide 11 can be formed as a matt surface and the transparent resin layer 20A may be omitted. To provide a matt surface, those materials that function as Fresnel lens, lenticular lens, other lenses, prism, etc., and those having a rough surface area formed into a specified pattern can be used.

[0025] In the following, manufacturing method of the light control element of the present invention is explained. As shown in the above-mentioned each application example, in the light control element of the present invention, multiple transparent flakes 16 having a flat surface are arranged at a specified angle inside a light guide made of a transparent resin. In order to arrange transparent flake 16 in the specified direction, a special nozzle is used during extrusion molding of the hot-melt synthetic resin containing transparent flake 16.

[0026] Fig. 15 is a perspective view that shows the structure of nozzle 26 used, and

Fig. 16 shows the cross section for section XVI-XVI in Fig. 15. Fig. 16 shows the cross section view of nozzle 26 used for production of the light control element described in Fig. 1, and transparent flake 16 is arranged in such a manner that an angle other than 90° can be achieved for front surface 12 and back surface 14. In other words, casing 28 of nozzle 26 has a rectangular cross section, but multiple partitions 30 are installed inside the nozzle and are used for dividing the rectangle into multiple parallelograms. In other words, each partition 30 is attached at an angle other than 90°C with respect to long side 32 of the casing.

[0027] Therefore, when a molten synthetic resin containing transparent flake 16 passes through nozzle 26, transparent flake 16 flows as it becomes oriented along the surface of the wall of partition 30; thus, it is arranged perpendicular to the partition at or near the exit of the nozzle as shown in the figure. The molten synthetic resin released from the nozzle 26 is cast onto a frame used for formation of the sheet, which is not shown in the figure, and subsequently solidified. It should be noted that the area with specified thicknesses T1 and T2 near the front surface and the back surface that correspond to front surface 12 and back surface 14 of the light guide, are cut off after solidification as shown in Fig. 17. The reason is that transparent flake 16 that has an orientation that is not parallel to partition 30 exists near the front and back surfaces, therefore, said area is cut off, and the area that runs perpendicular to the partitions 30 alone is used. In this manner, the light control element of the application example shown in Fig. 1 can be produced. It should be noted that the angle of the partition 30 should be set based on the desired direction orientation of the transparent flake 16, thus, a desired angle of orientation can be obtained.

[0028] Fig. 18 shows the cross section view of a nozzle, which is a modified version of the nozzle shown in Fig. 16. Partition 30 is installed at an angle of 90° along the long side of the casing 34 of the nozzle. When a molten synthetic resin containing transparent flake 16 is extruded into a frame that is not shown in the figure, transparent flake 16 is oriented perpendicular to partition 36, and when the area near the front and back surfaces formed along the long side is removed as described above after solidification, the light control element of an application example shown in Fig. 3 can be produced.

[0029] The longer the ratio between the long side and short side of the parallelogram produced by partition 30 shown in Fig. 16 and the rectangle produced by partition 36 shown in Fig. 18, the more desirable from the standpoint of orientation of the transparent flake 16. For example, when the above-mentioned ratio is set for 4:1 or 3:1, orientation of transparent flake 16 can be achieved. On the other hand, when the above-mentioned ratio is 2:1 or below, the desired orientation is less likely to be achieved, thus, it is important to set it to be 2:1 or higher.

[0030]

[Effect of the invention] As described above, according to the light control element of the present invention, a multitude of transparent flakes are arranged and dispersed at an angle other than 0° in a light guide having a flat surface. Thus, a desired light control can be achieved for a variety of incident rays through an adjustment of the above-mentioned angle. The element used has a flat surface, therefore, adhesion with other optical parts is made easy, furthermore, side face can be used for incident ray and emission of light as well as the front surface and back surface. Furthermore, transmission loss of light is low, and

the dimensions can be freely changed, thus, a compact form can be produced. Furthermore, according to the manufacturing method of the light control element of the present invention and machine used for production of the light control element, it is possible to produce easily the light control element of the present invention with a uniform orientation.

[Brief explanation of the figures]

[Fig. 1] The figure is a partial cross section that shows an application example of the light control element of the present invention.

[Fig. 2] The figure is a perspective view that shows the basic lead carbonate monocrystal.

[Fig. 3] The figure is a partial cross section view that shows an application example when transparent flake 16 is arranged in the perpendicular orientation to front surface 12 and back surface 14. [Fig. 4] The figure is the partial cross section view that shows the case where transparent flake 16 is arranged at an angle other than 90° to surface 12 of the light guide 11.

[Fig. 5] The figure shows the partial cross section view in the traveling direction of the incident ray after being reflected by transparent flake 16 as the incident ray enters perpendicular to the surface 12 of light guide 11.

[Fig. 6] The figure is a partial cross section view that shows the case where the light control element of the present invention is used as a polarizer for separation of the P wave and S wave.

[Fig. 7] The figure is the partial cross-section view of the polarized diffusion plate made of the light control element of the present invention used as a liquid crystal display.

[Fig. 8] The figure is the diagram that shows the light control element of the present invention applied to the headlights of an automobile..

[Fig. 9] The figure shows the partial cross section view of an application example where a layer 20, comprised of a material such as transparent resin, is applied to one surface of light guide 11 of the light control element 10 of the present invention, and removal of the S wave is made easy.

[Fig. 10] The figure shows a partial cross section view of an application example where, in addition to the structure shown in Fig. 9, λ/4 sheet or λ/4 film 11 is applied to the outer surface of transparent resin layer 20, and mirror 24 is further applied to said surface for mirror reflection.

[Fig. 11] The figure is the partial cross section view that shows the state where an S wave was applied to the structure shown in Fig. 9.

[Fig. 12] The figure is the partial cross section view that shows the state where P wave was applied to the structure shown in Fig. 9.

[Fig. 13] The figure is the partial cross section view that shows the case where mirror 24 that functions as a mirror reflecting surface is applied to the entire surface of the element of the application example shown in Fig. 3.

[Fig. 14] The figure is the cross section view that shows a modified case the application example shown in Fig. 9.

[Fig. 15] The figure is the perspective view that shows the structure of nozzle 26

[Fig. 16] The figure shows a cross section view at section XVI-XVI in Fig. 15.

[Fig. 17] The figure is the cross section view of the material formed during the process of manufacturing the light control element of the present invention.

[Fig. 18] The figure shows the cross section view of a nozzle, which is a modified version of the nozzle shown in Fig. 16.

[Explanation of codes]

10: light control element

11: Light guide

12: Surface of the light guide

14: Backside of the light guide

16: Transparent flake

18: Side surface of light guide 11

19: Polarized diffusion plate

20: Transparent resin layer

21: Polarized film

22: λ/4 plate

23: Headlight

25: Road surface

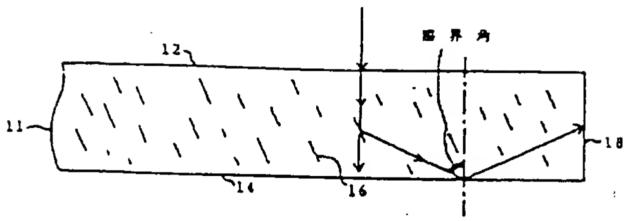
26: Nozzle

28, 34: Casings

30, 36: Partitions

32, 38: Long side

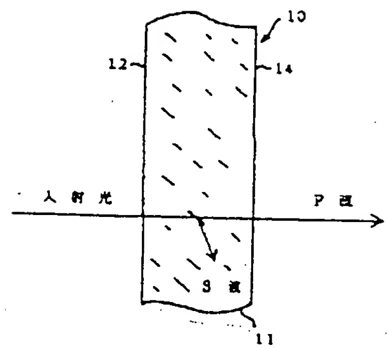
[Fig. 5]



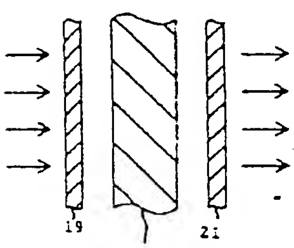
Dotted line: Normal

Indicated angle: Critical angle

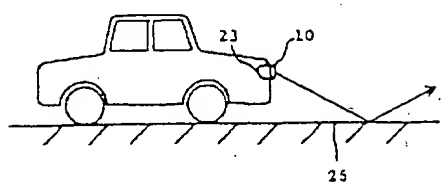
[Fig. 6]



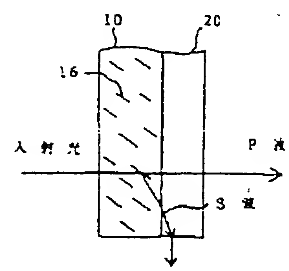
[Fig. 7]



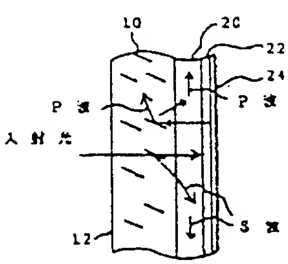
[Fig. 8]



[Fig. 9]

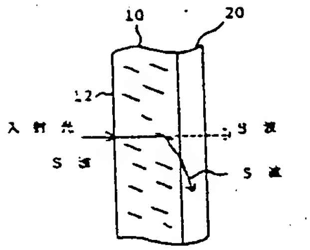


[Fig. 10]



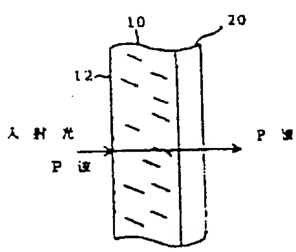
[Fig. 11]

(Light released from the front face is reduced)

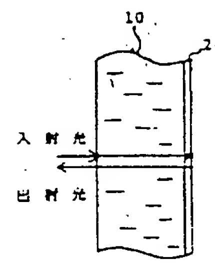


[Fig. 12]

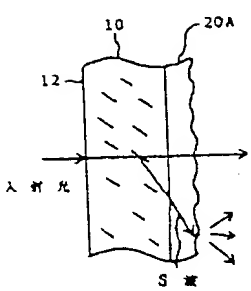
(Light released from the front face alone)



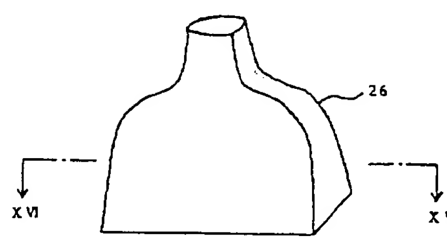
[Fig. 13]



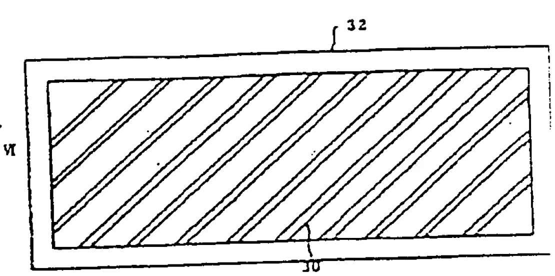
[Fig. 14]



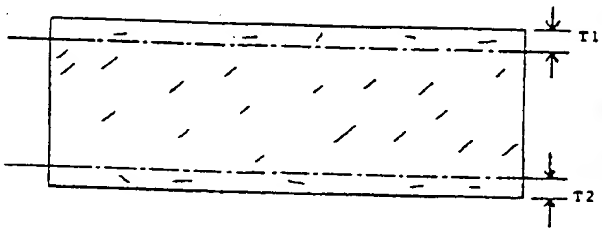
[Fig. 15]



[Fig. 16]



[Fig. 17]



[Fig. 18]